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## PROJECT THOR

TECHNICAL REPORT NO. 6

MARCH 1952

PRESENTED AREAS  
OF AN AVERAGE  
PRONE CHINESE INFANTRYMAN

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Project TP3-0238A  
Ballistic Research Laboratories  
Aberdeen Proving Ground, Md.

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PRESERVED AREAS OF AN AVERAGE  
PRONE CHINESE INFANTRYMAN

PROJECT THOR TECHNICAL REPORT NO. 6

March, 1952

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Institute for Cooperative Research  
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Baltimore 2, Maryland

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Project TB3-0238A  
Ballistic Research Laboratories  
Aberdeen Proving Ground, Maryland

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PRESENTED AREAS OF AN AVERAGE  
PRONE CHINESE INFANTRYMAN

**ABSTRACT**

For evaluation of weapons used against personnel, the average presented area of a typical Chinese infantryman prone on the ground is given as a function of the angle of arrival of fragment or bullet. World War I dimensions of the average United States infantryman were scaled by a relative stature factor to represent those of the average Chinese infantryman. Some applications of the results are suggested.

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PRESENTED AREAS OF AN AVERAGE  
PRONE CHINESE INFANTRYMAN

INTRODUCTION

Studies of the effectiveness of weapons for attack of ground troops require knowledge of the target presented area. The presented area of the infantryman is a function of his dimensions, his position on the ground, and the angle of arrival of the fragment or bullet. The purpose of this report is to determine for a prone posture the average presented area of a typical Chinese infantryman as a function of the angle of arrival. Previously, an estimated value of the vulnerable area has been used.

METHOD OF SOLUTION

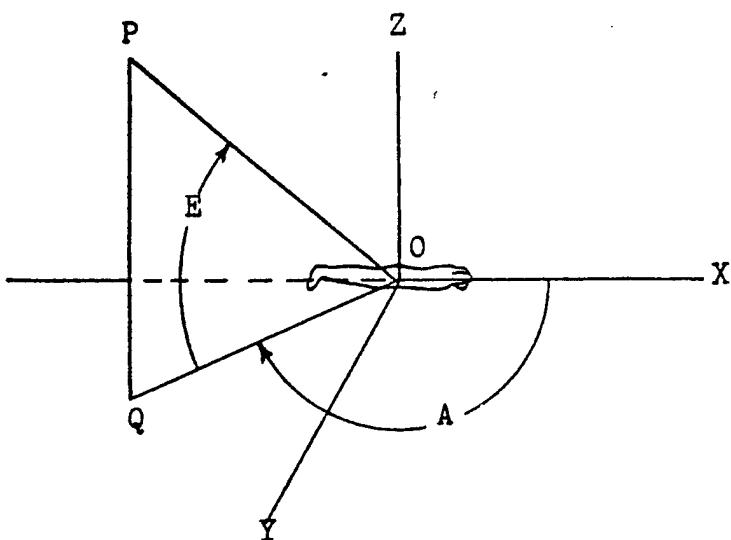
Determination of Chinese Infantryman Dimensions

The physical characteristics of a typical Chinese infantryman were not available. However, physical dimensions of the mean United States infantryman of World War I (Ref. 1)

and the mean Japanese infantryman stature of the same period were located (Ref. 2). The assumption was made that the typical Japanese and Chinese prone infantrymen are dimensionally identical. In studies made of the physical characteristics of man, particular emphasis has been placed on stature. Therefore, the average U.S. infantryman measurements were scaled (App.: Fig. 2) by a factor (0.9200) representing the ratio of mean statures of the Japanese and U.S. infantrymen.

#### Definition of Angle of Elevation and Azimuth

The angle of elevation E, i.e. the angle of arrival of the fragment or bullet, is defined as the angle QOP made by the line of approach PO of the fragment or bullet and the XY plane. Azimuth A is the angle XOQ between the projection QO of the path of the bullet on the XY plane and the longitudinal axis of the target. Directions are defined below.



## Experimental Techniques and Results

To determine the presented areas of the Chinese infantryman, photographs were taken of a model and the results planimetered. The model was constructed of wood to the scale one to ten. It represents the target in a prone position with legs fairly straight and arms wound about the head for protection. Lines were drawn on the model to indicate head, torso, limbs, and abdomen. This marking will facilitate the computation of vulnerable areas when kill probabilities for these portions of the body are available.

The presented area of the target is a function f of the azimuth and the angle of elevation. With respect to presented area the target is symmetrical about its longitudinal axis, that is

$$f(A, E) = f(A + 180^\circ, -E).$$

Furthermore, the presented area is taken to be symmetrical about a vertical plane passing through this longitudinal axis, that is

$$f(A, E) = f(360^\circ - A, E).$$

Photographs of the model were taken for selected values of azimuth and elevation at a fixed distance of four feet from the model centroid. Because of the symmetry mentioned above, these selections were made in the region  $0 \leq A \leq 180^\circ$ ,  $0 \leq E \leq 90^\circ$  covering in effect the entire

surface of the sphere. The silhouettes (App.: Fig. 2) were planimetered and the areas obtained were multiplied (App.: Fig. 5) by appropriate factors to give the presented area (sq ft) of the Chinese infantryman.

For each fixed angle of elevation the presented area of the Chinese infantryman was plotted (App.: Fig. 6) as a continuous function of azimuth and an average area was computed. A graph (App.: Fig. 7) of average presented area as a function of angle of elevation was then constructed.

#### APPLICATIONS

The material presented here can be adapted for several applications, of which the following are examples:

A. If the height<sup>1</sup> of the characteristic member of another racial group is known, then the presented area of this individual in a prone position for a particular aspect can be found by multiplying the corresponding result in the text by the square of the relative stature factor.

B. To determine the effect of shielding by terrain or equipment, the exposed area may be altered on the photographs and the unshielded areas planimetered.

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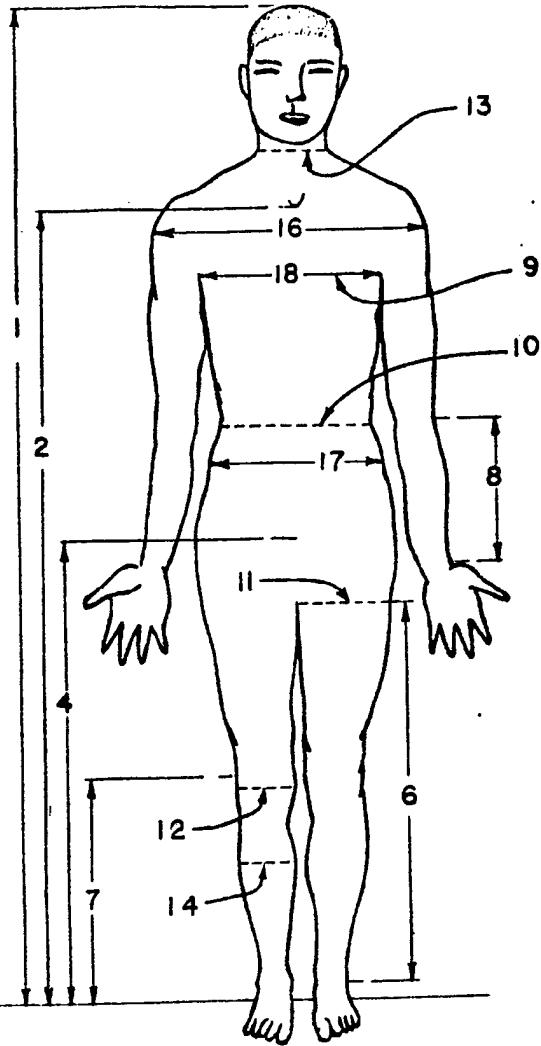
<sup>1</sup> Mean heights of men from a wide variety of racial groups have been compiled in Reference No. 3.

C. To obtain the vulnerable area of the prone Chinese infantryman, the photographs can be examined to find the presented areas of the bodily portions. Then the corresponding conditional kill probabilities can be applied, and the products summed.

D. To approximate roughly the average presented area of the characteristic Chinese infantryman in an upright position as a function of the angle of arrival of fragment or bullet, the graph of presented area as a function of aspect (App.: Fig. 6) can be used. The aspects ( $a, e$ ) selected for the standing man are transformed into the corresponding aspects ( $A, E$ ) for the prone man and the associated presented areas averaged.

**APPENDIX**

Fig. 1



VERTICAL DIMENSIONS

1. Stature
2. Sternal Notch
3. Sitting Height
4. Pubis

LIMB LENGTHS

5. Arm (spine to wrist, forearm flexed)
6. Leg
7. Knee Height (when seated)
8. Forearm

CIRCUMFERENCES

9. Chest
10. Waist
11. Thigh (maximum)
12. Kneecap
13. Neck
14. Calf (maximum)

TRANSVERSE DIAMETERS

15. Span (Maximum)
16. Shoulder
17. Hip
18. Chest

FORE AND AFT DIAMETER

19. Chest

Fig. 2

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## MEAN DIMENSIONS OF INFANTRYMEN

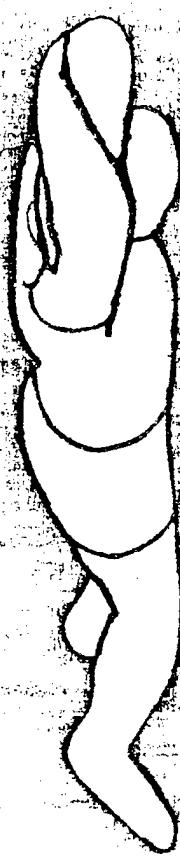
Dimension Number (See Fig. 1)	American <sup>1</sup> Infantryman, World War I (in.)	Chinese <sup>2</sup> Infantryman, 1915 (in.)	Specifications <sup>3</sup> for Chinese Infantryman Wooden Model (in.)
1	67.72	62.30	6.23
2	55.58	51.13	5.11
3	35.59	32.7 <sup>4</sup>	3.27
4	34.18	31.45	3.14
5	30.87	28.40	2.84
6	28.22	25.96	2.60
7	18.54	17.06	1.71
8	10.59	9.74	0.97
9	34.96	32.16	3.22
10	30.66	28.21	2.82
11	20.75	19.09	1.91
12	14.26	13.12	1.31
13	14.16	13.03	1.30
14	13.42	12.35	1.24
15	69.13	63.60	6.36
16	16.46	15.14	1.51
17	11.59	10.66	1.07
18	11.42	10.51	1.05
19	8.50	7.82	0.78

<sup>1</sup> Approximately 100,000 sample size (Ref. 1)<sup>2</sup> Computed by application of relative stature factor (0.9200)<sup>3</sup> Scale one to ten~~RECORDED~~

- Fig. 3  
SILHOUETTES OF WOODEN MODEL

ELEVATION 0  
AZIMUTH 0

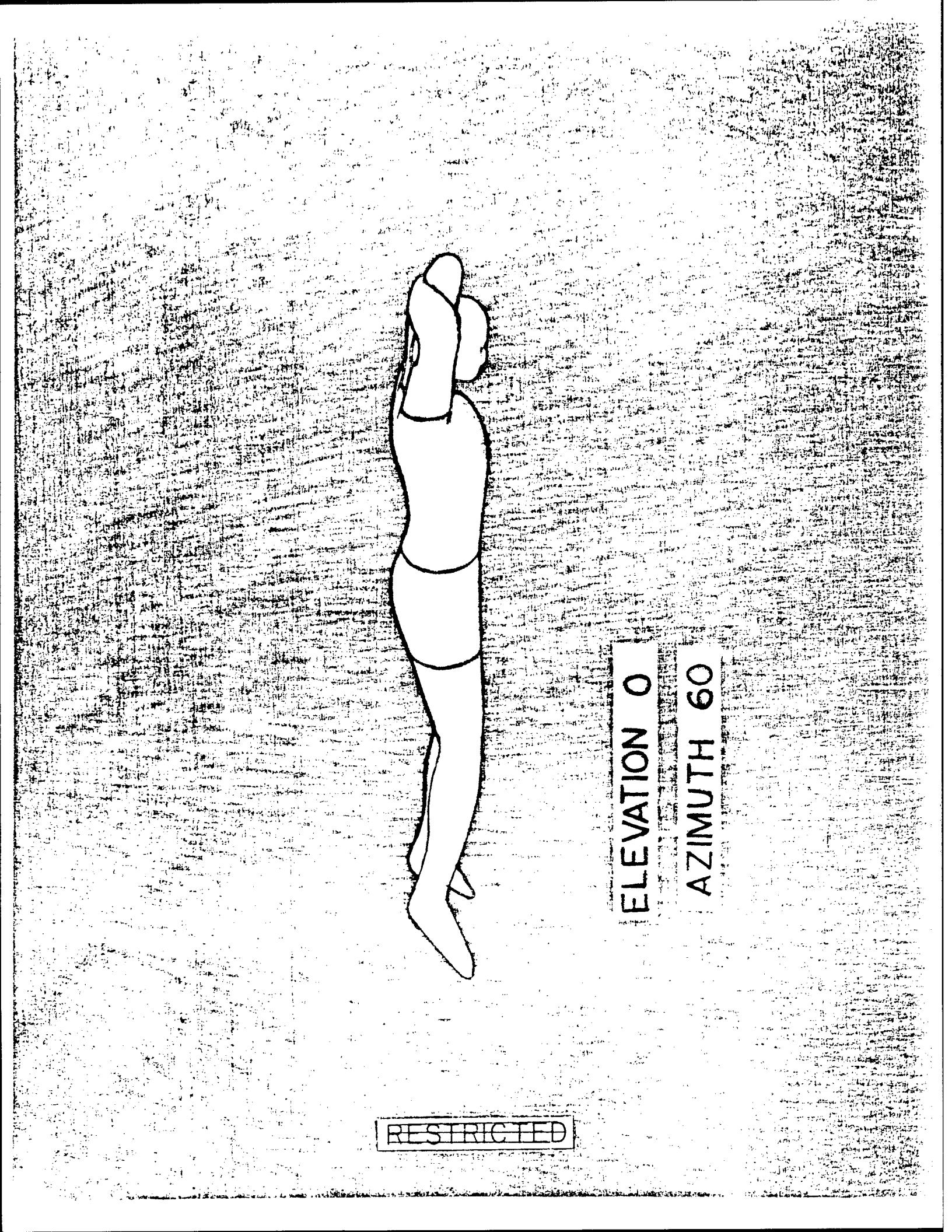
RESTRICTED



ELEVATION 0

AZIMUTH 30

RESTRICTED



ELEVATION 0  
AZIMUTH 60

RESTRICTED

ELEVATION 0  
AZIMUTH 90

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ELEVATION 0

AZIMUTH 120

RESTRICTED



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ELEVATION 0

AZIMUTH 150

ELEVATION 0

AZIMUTH 180

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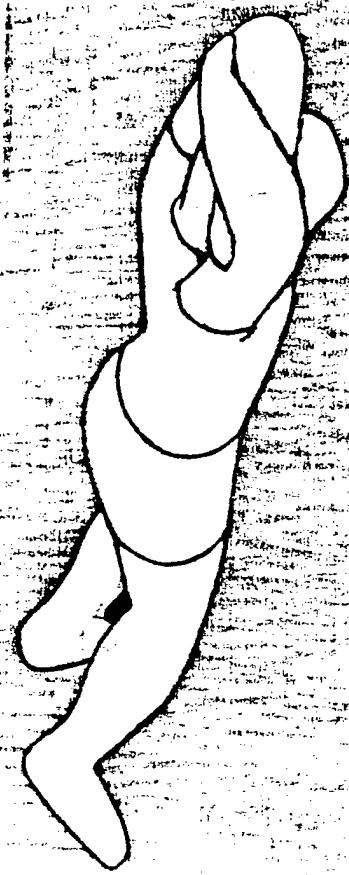
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AZIMUTH 0

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ELEVATION 10

AZIMUTH 30



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ELEVATION 10

AZIMUTH 60

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ELEVATION 10

AZIMUTH 90

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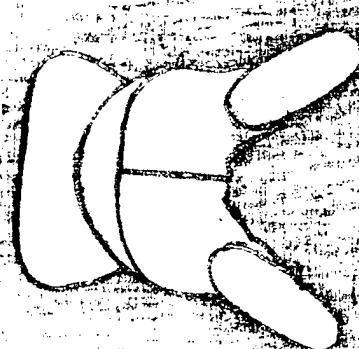
ELEVATION 10  
AZIMUTH 120

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ELEVATION 10

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ELEVATION 10  
AZIMUTH 180



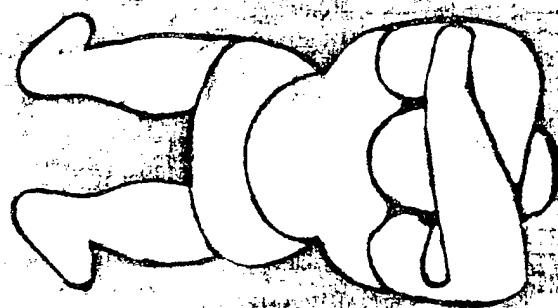
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ELEVATION 20

AZIMUTH 30

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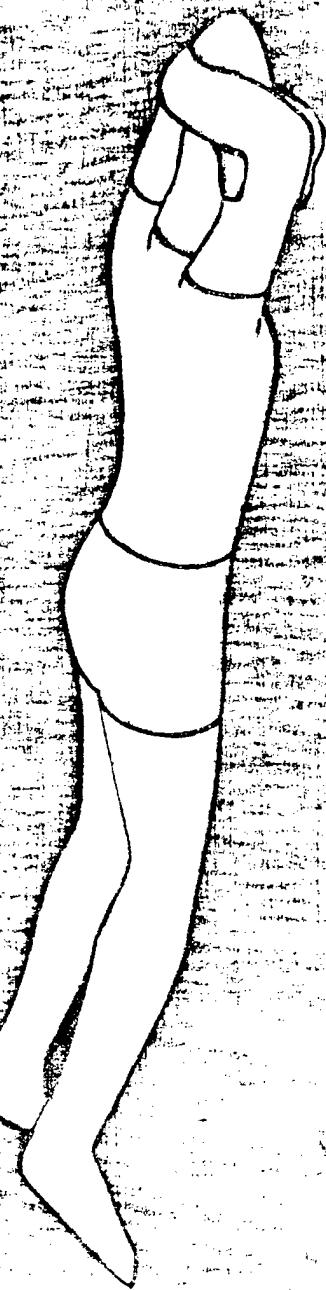
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AZIMUTH 0



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ELEVATION 20

AZIMUTH 60



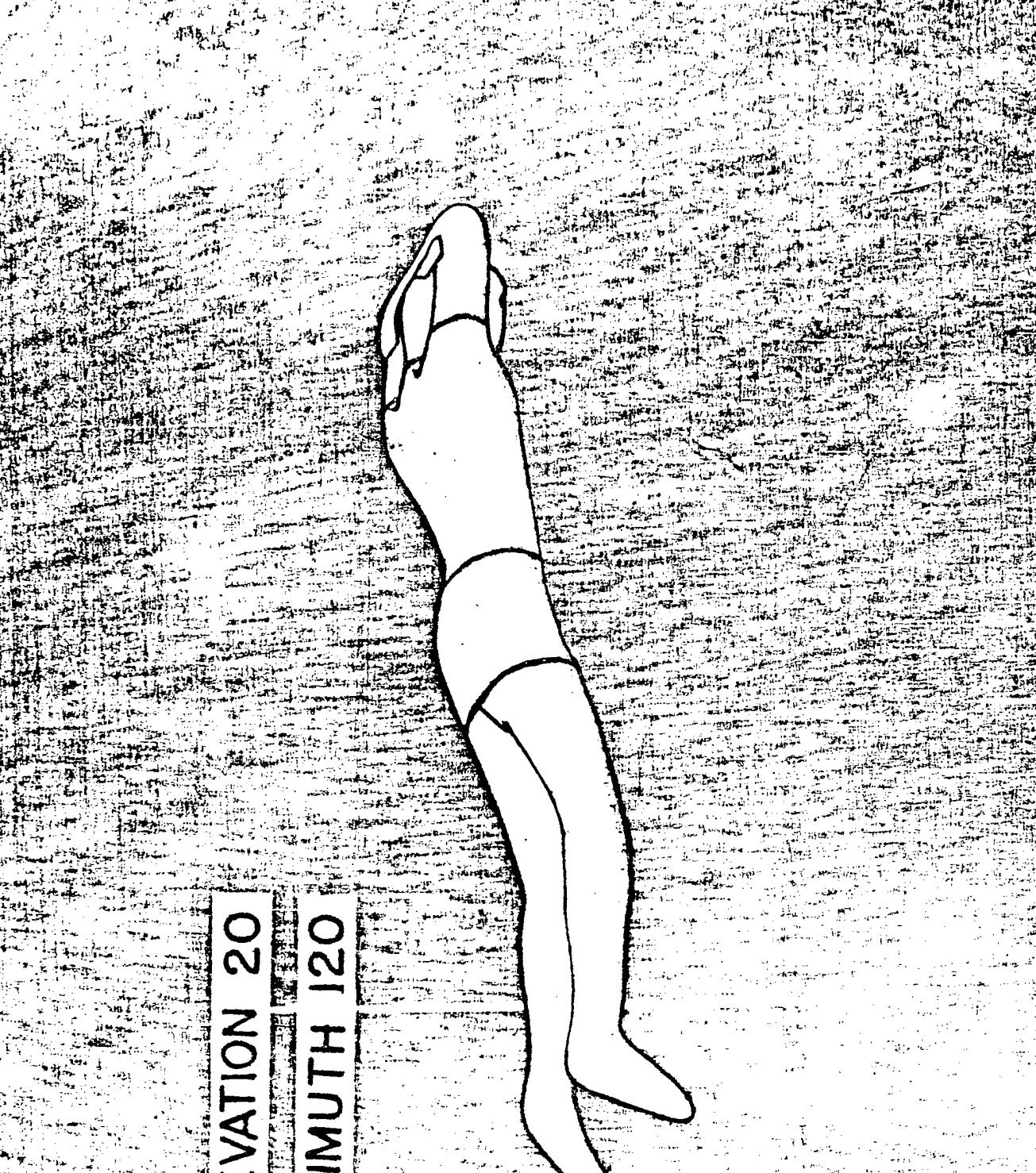
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ELEVATION 20

AZIMUTH 30



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ELEVATION 20  
AZIMUTH 120

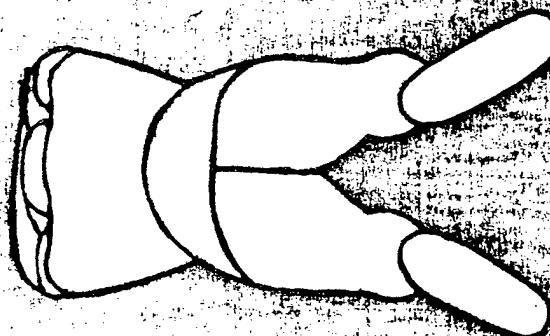
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ELEVATION 20  
AZIMUTH 150

RESTRICTED

ELEVATION 20

AZIMUTH 180



RESTRICTED

ELEVATION 30  
AZIMUTH 0

RESTRICTED

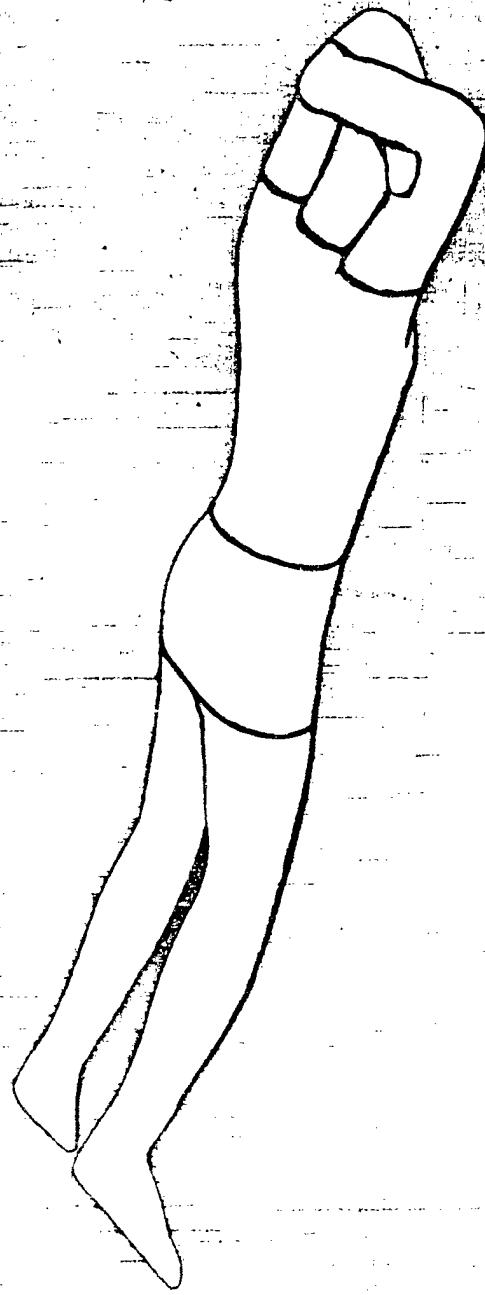
ELEVATION 30

AZIMUTH 30

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ELEVATION 30

AZIMUTH 60



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ELEVATION 30

AZIMUTH 90

RESTRICTED

ELEVATION 30  
AZIMUTH 120

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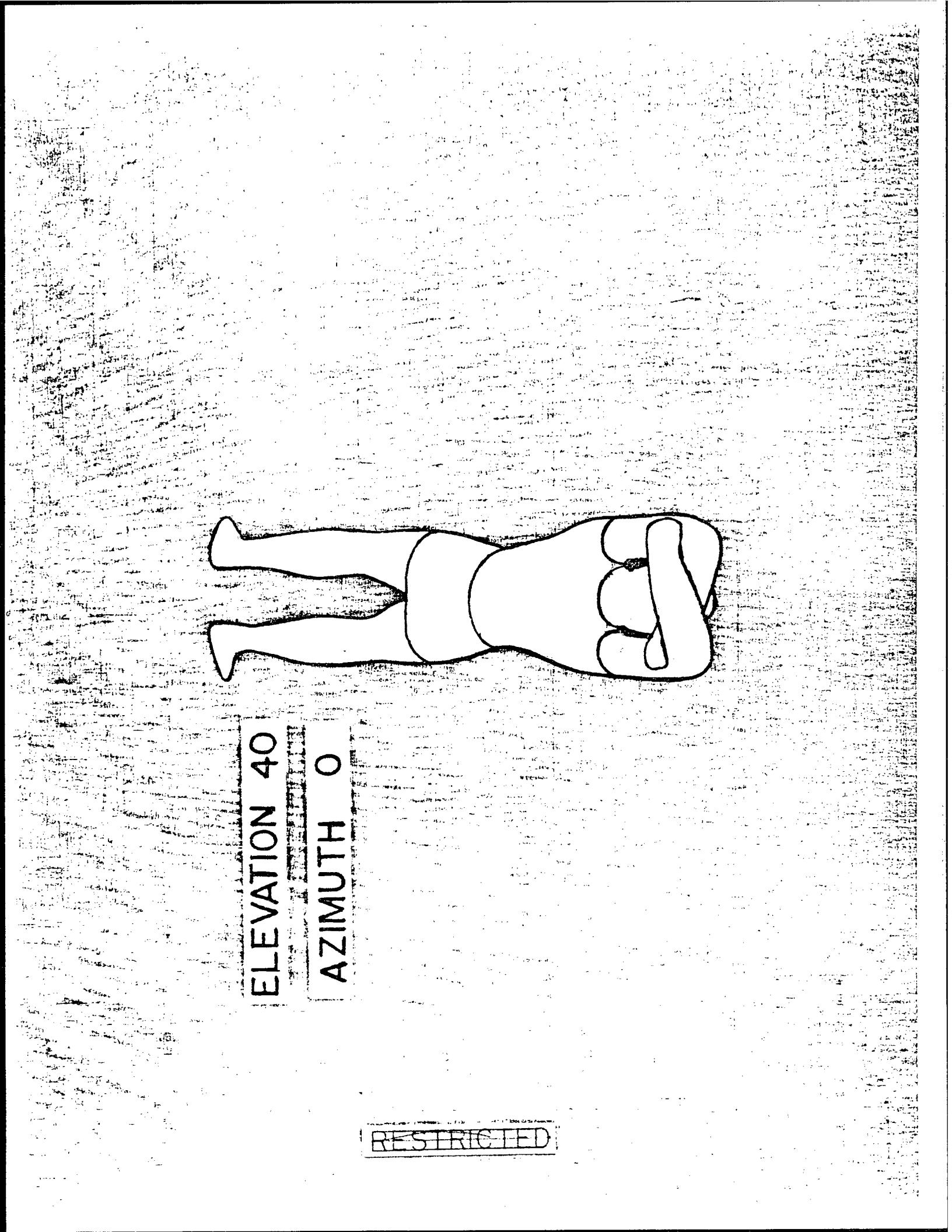
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ELEVATION 30  
AZIMUTH 180

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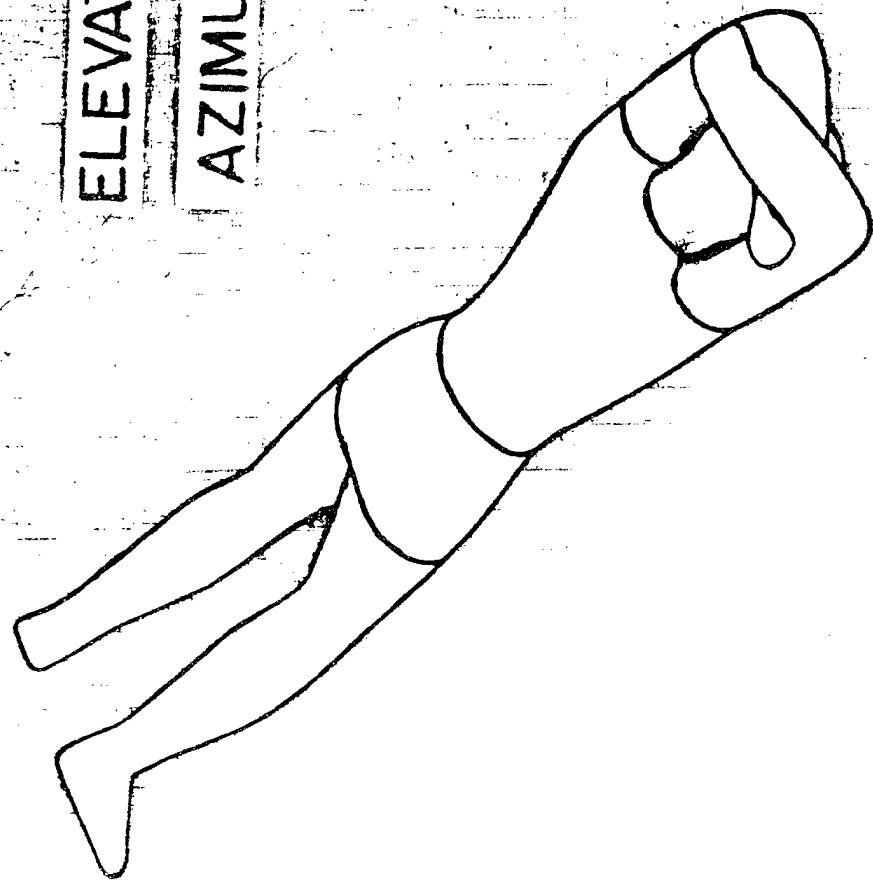


ELEVATION 40  
AZIMUTH 0

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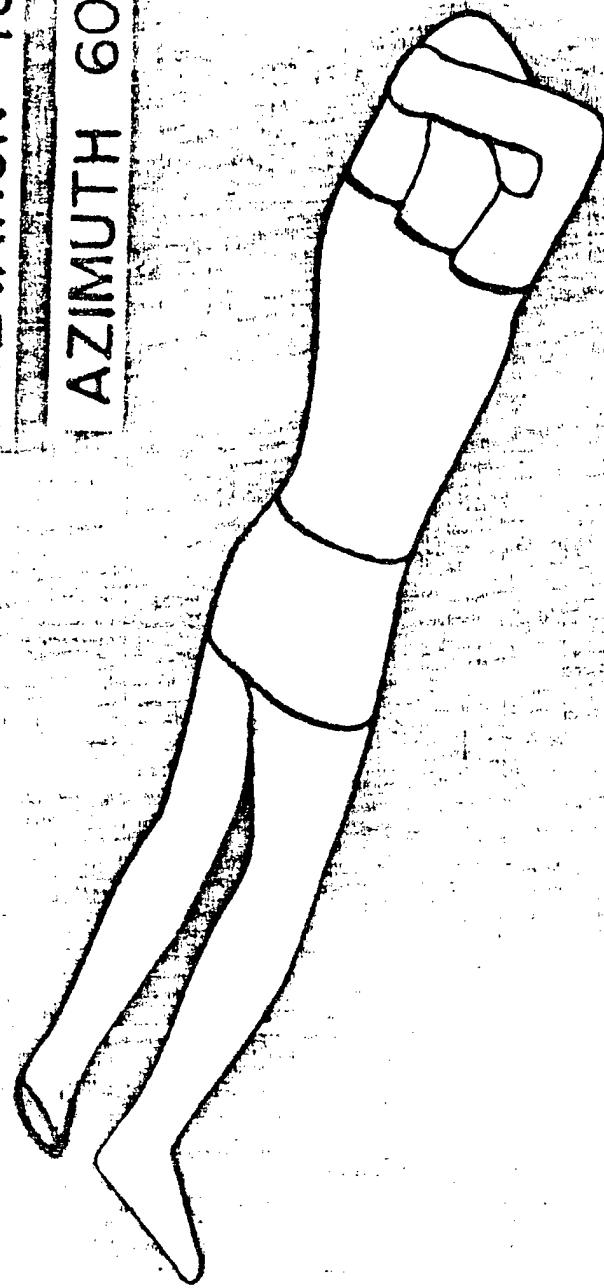
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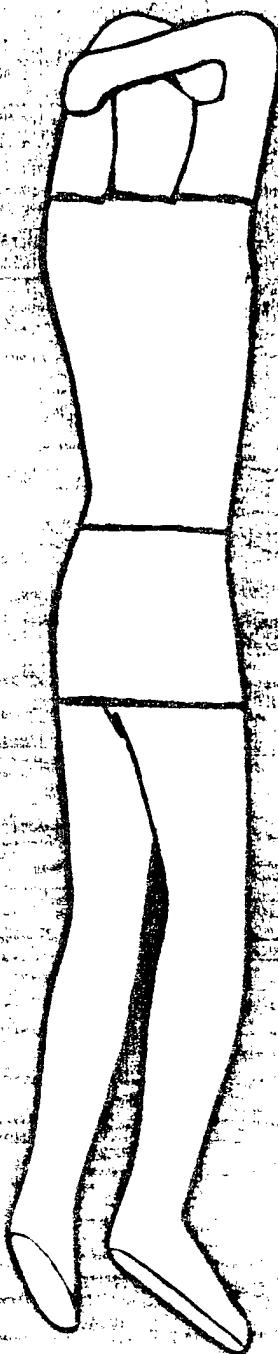
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AZIMUTH 60



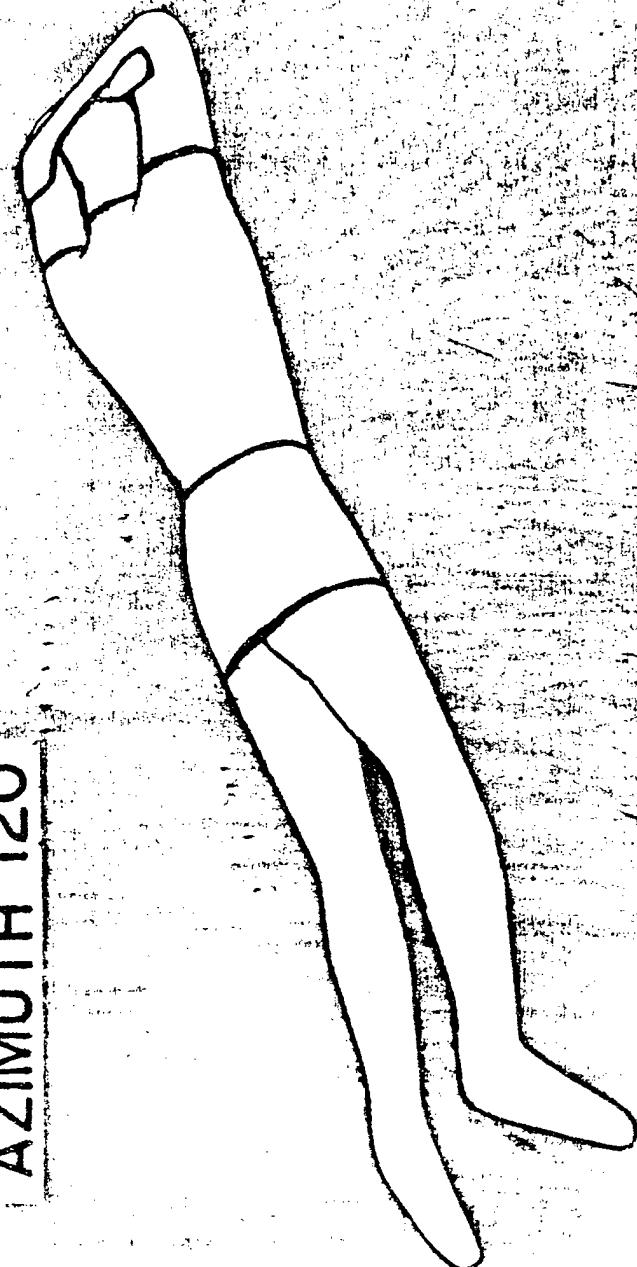
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**ELEVATION 40**

**AZIMUTH 90**



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ELEVATION 40

AZIMUTH 120

RESTRICTED

ELEVATION 40

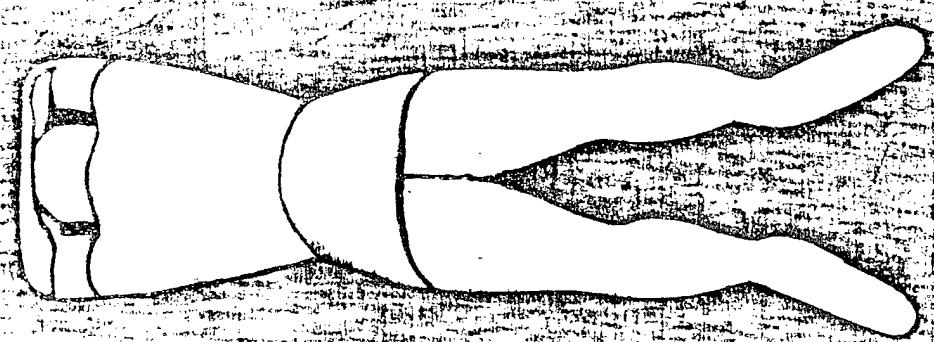
AZIMUTH 150

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ELEVATION 55

AZIMUTH 0

RESTRICTED



ELEVATION 40  
AZIMUTH 180

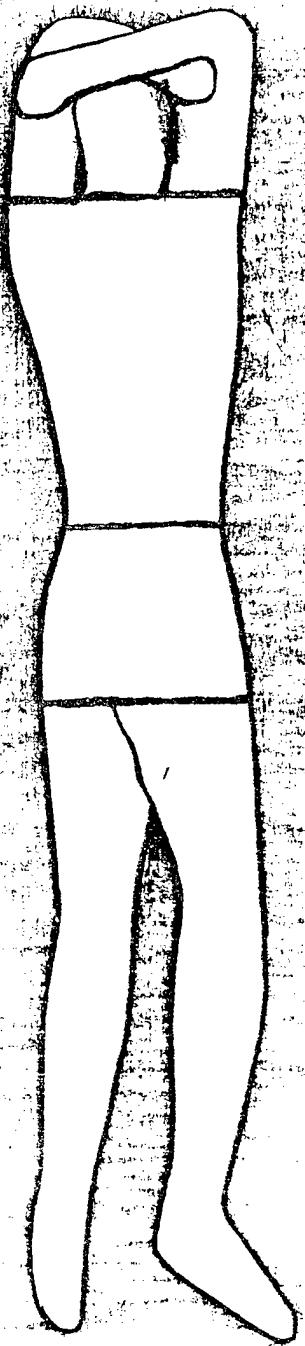
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ELEVATION 55

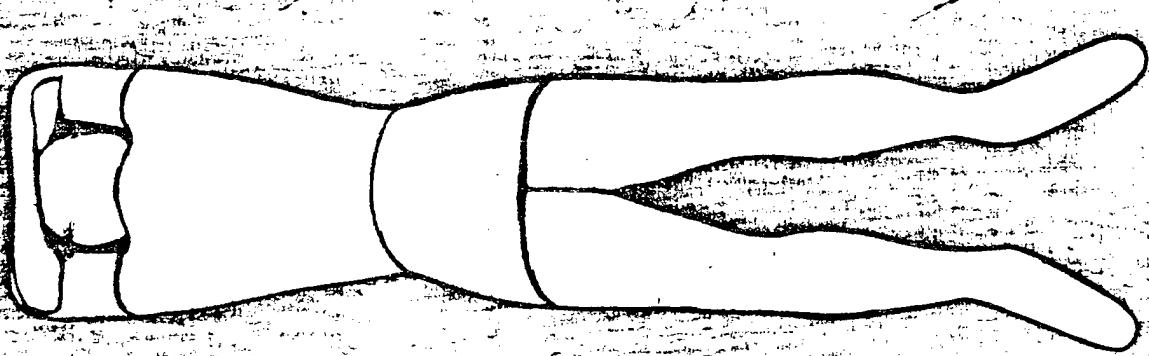
AZIMUTH 45

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ELEVATION 55  
AZIMUTH 90



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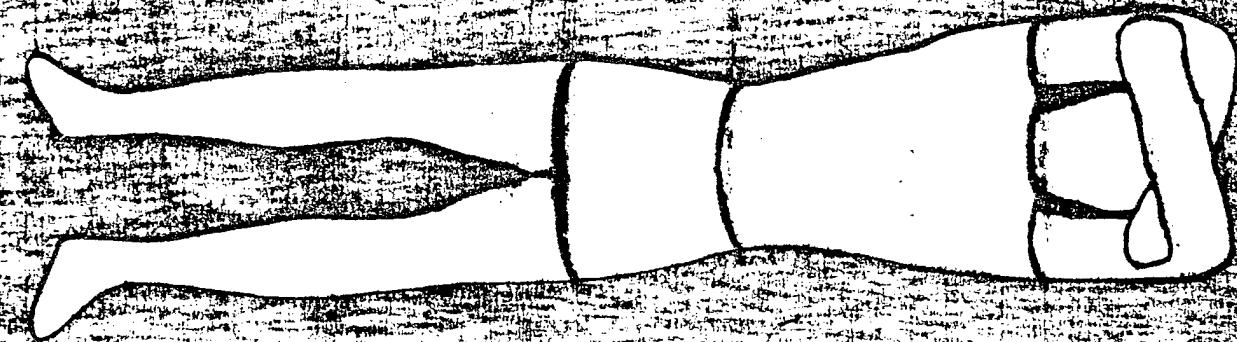
ELEVATION 55  
AZIMUTH 180

RESTRICTED

ELEVATION 55

AZIMUTH 135

RESTRICTED



ELEVATION 70  
AZIMUTH 0

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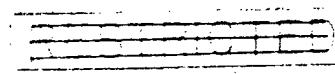
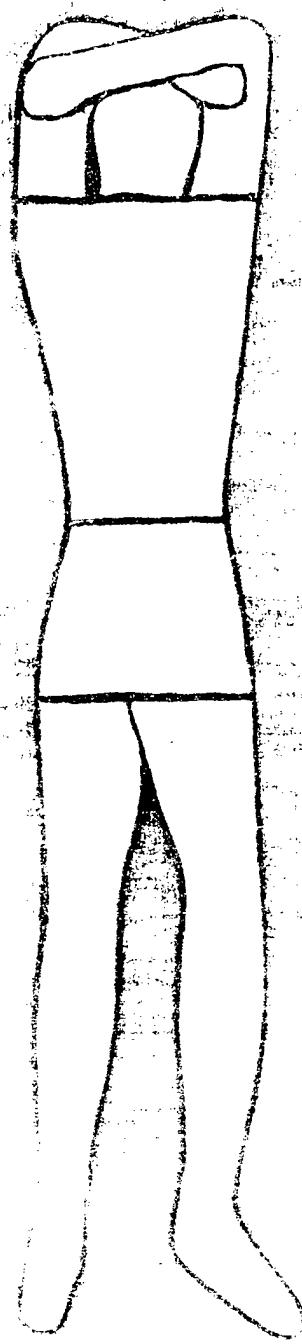
ELEVATION 70

AZIMUTH 45

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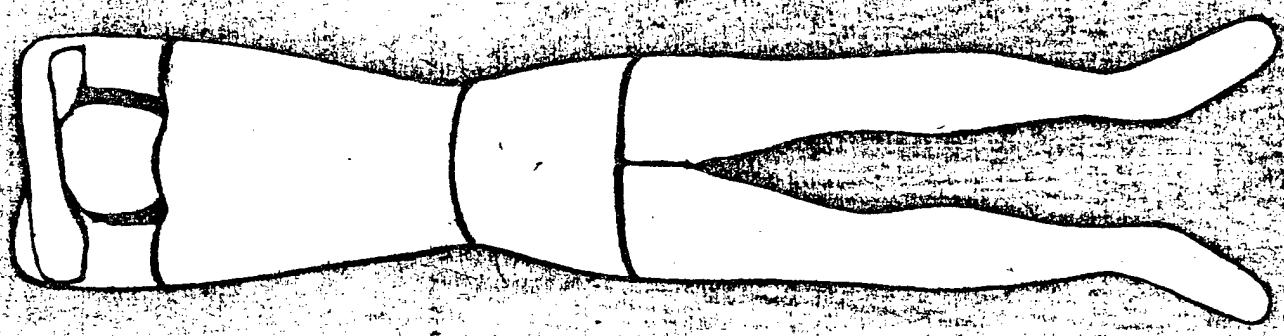
ELEVATION 70

AZIMUTH 90



ELEVATION 70  
AZIMUTH 135

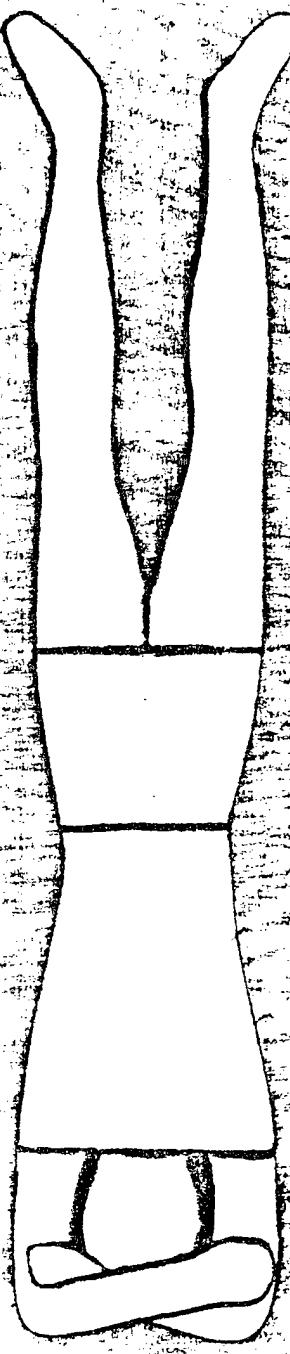
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ELEVATION 70  
AZIMUTH 180

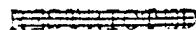
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ELEVATION 90



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Fig. 4



#### SCALING FACTOR

It was impractical to control the duplication processes such that each silhouette (Fig. 3) would have the same scale as the model. Consequently a scaling factor  $F$  has been introduced to obtain the presented area of the model, as follows:

$$W = S \cdot F$$

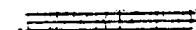
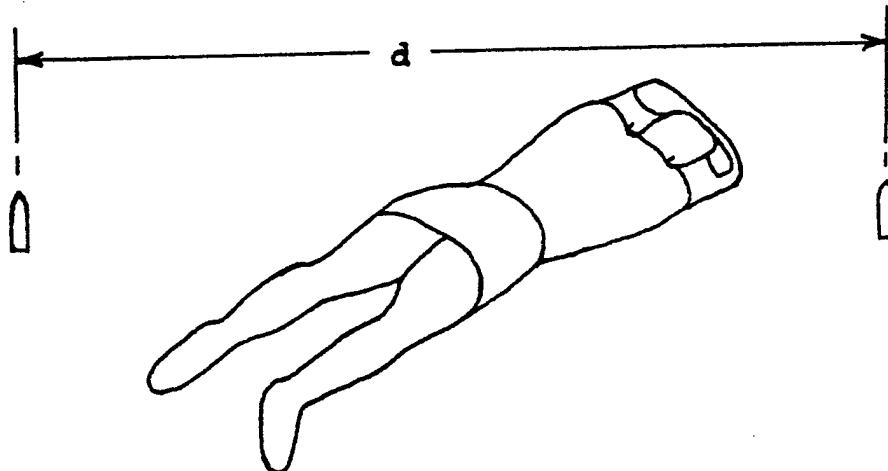
$$\text{where } F = \left(\frac{c}{d}\right)^2$$

and  $W$  = presented area of wooden model (1/10 full size)

$S$  = planimetered area of silhouette (From Fig. 3)

$d$  = distance between markers on the reproduction  
(see below)

$c$  = constant distance between markers during  
photographing (8 inches for all aspects).



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## PRESENTED AREAS

Elevation (deg)	Azimuth (deg)	Planimetered Area of Silhouette (Fig. 3) (sq in.)	Scaling Factor (Fig. 4)	Presented Area of Wooden Model (sq in.)	Presented Area of Chinese Infantry- man. (sq in.)	Presented Area of Chinese Infantry- man (sq ft)
0	0	1.04	0.985	1.02	102	0.71
0	30	2.52	1.032	2.60	260	1.81
0	60	3.75	1.000	3.75	375	2.60
0	90	3.90	0.985	3.84	384	2.67
0	120	3.78	0.985	3.72	372	2.58
0	150	2.75	0.985	2.71	271	1.88
0	180	0.99	1.032	1.02	102	0.71
						(Avg.) 2.04
10	0	1.81	0.969	1.75	175	1.22
10	30	3.06	1.000	3.06	306	2.12
10	60	4.24	0.969	4.11	411	2.85
10	90	4.47	0.969	4.33	433	3.01
10	120	4.15	0.969	4.02	402	2.79
10	150	2.91	0.969	2.82	282	1.96
10	180	1.67	0.969	1.62	162	1.12
						(Avg.) 2.32

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Fig. 5  
(Cont'd)

Elevation	Azimuth	Planimetered Area of Silhouette (Fig. 3) (sq in.)	F	S·F	100(S·F)	$\frac{100(S·F)}{144}$
20	0	3.00	0.969	2.91	291	2.02
20	30	3.73	0.969	3.61	361	2.51
20	60	4.60	0.969	4.46	446	3.10
20	90	5.10	0.955	4.87	487	3.38
20	120	4.63	0.969	4.49	449	3.12
20	150	3.70	0.955	3.53	353	2.45
20	180	2.76	0.969	2.67	267	1.85
						(Avg.) 2.75
30	0	3.91	0.969	3.79	379	2.63
30	30	4.36	0.969	4.22	422	2.93
30	60	5.14	0.969	4.98	498	3.46
30	90	5.52	0.969	5.35	535	3.72
30	120	5.20	0.955	4.97	497	3.45
30	150	4.10	1.016	4.17	417	2.90
30	180	3.74	0.969	3.62	362	2.51
						(Avg.) 3.17

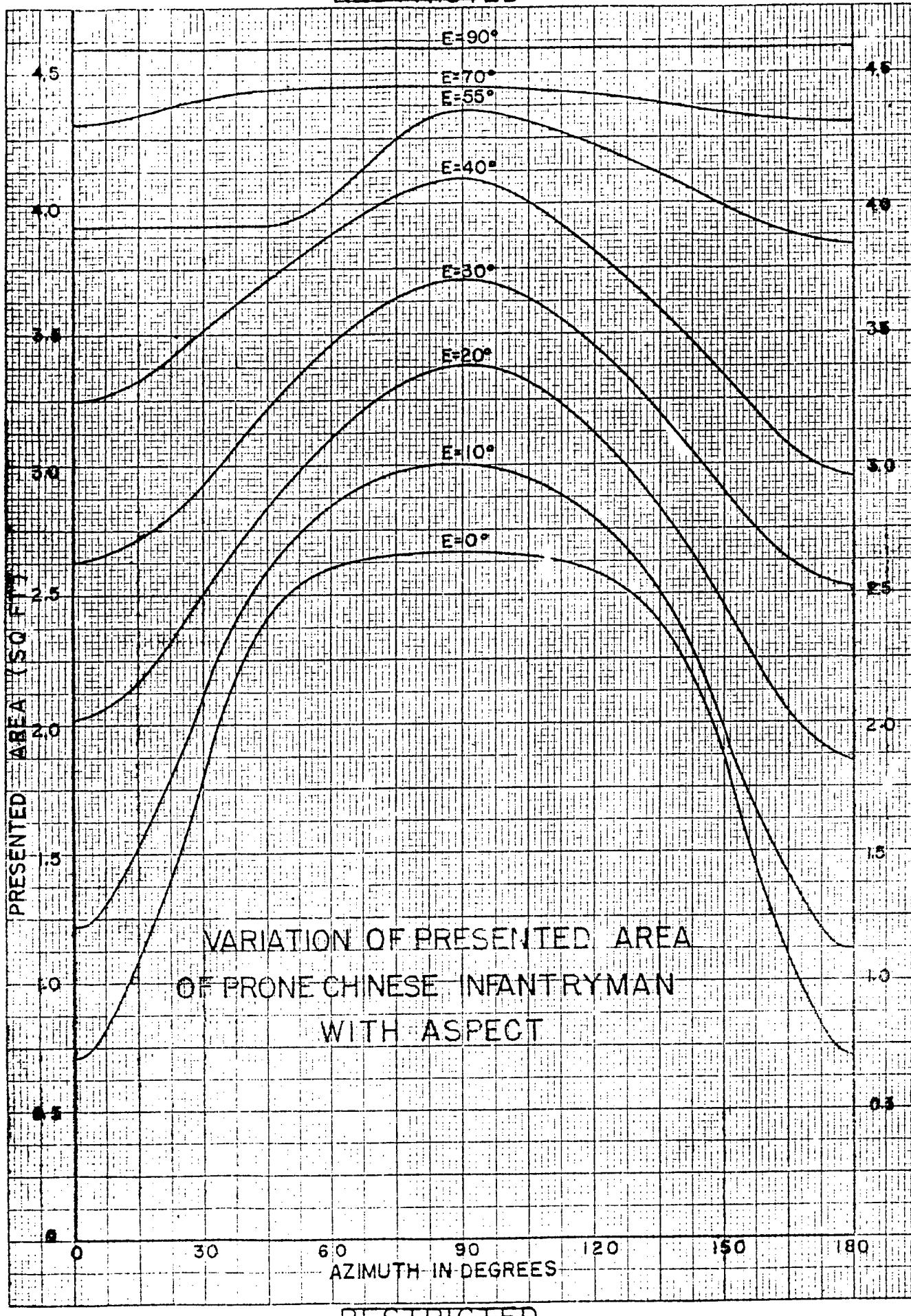
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Elevation (deg)	Azimuth (deg)	Planimetered Area of Silhouette (Fig. 3) (sq in.)	S	F	S·F	$\frac{100(S \cdot F)}{144}$	$\frac{100(S \cdot F)}{144}$
40	0	4.75	0.985	4.68	468	3.25	
40	30	5.23	0.969	5.07	507	3.52	
40	60	5.67	0.985	5.58	558	3.87	
40	90	5.98	0.985	5.89	589	4.09	
40	120	5.58	0.985	5.50	550	3.82	
40	150	4.96	0.969	4.81	481	3.34	
40	180	4.39	0.969	4.25	425	2.95	
					(Avg.)	3.62	
55	0	5.82	0.969	5.64	564	3.92	
55	45	5.64	1.000	5.64	564	3.92	
55	90	6.38	0.985	6.28	628	4.36	
55	135	6.01	0.985	5.92	592	4.11	
55	180	5.62	0.985	5.51	551	3.85	
					(Avg.)	4.06	

Fig. 5  
(Cont'd)

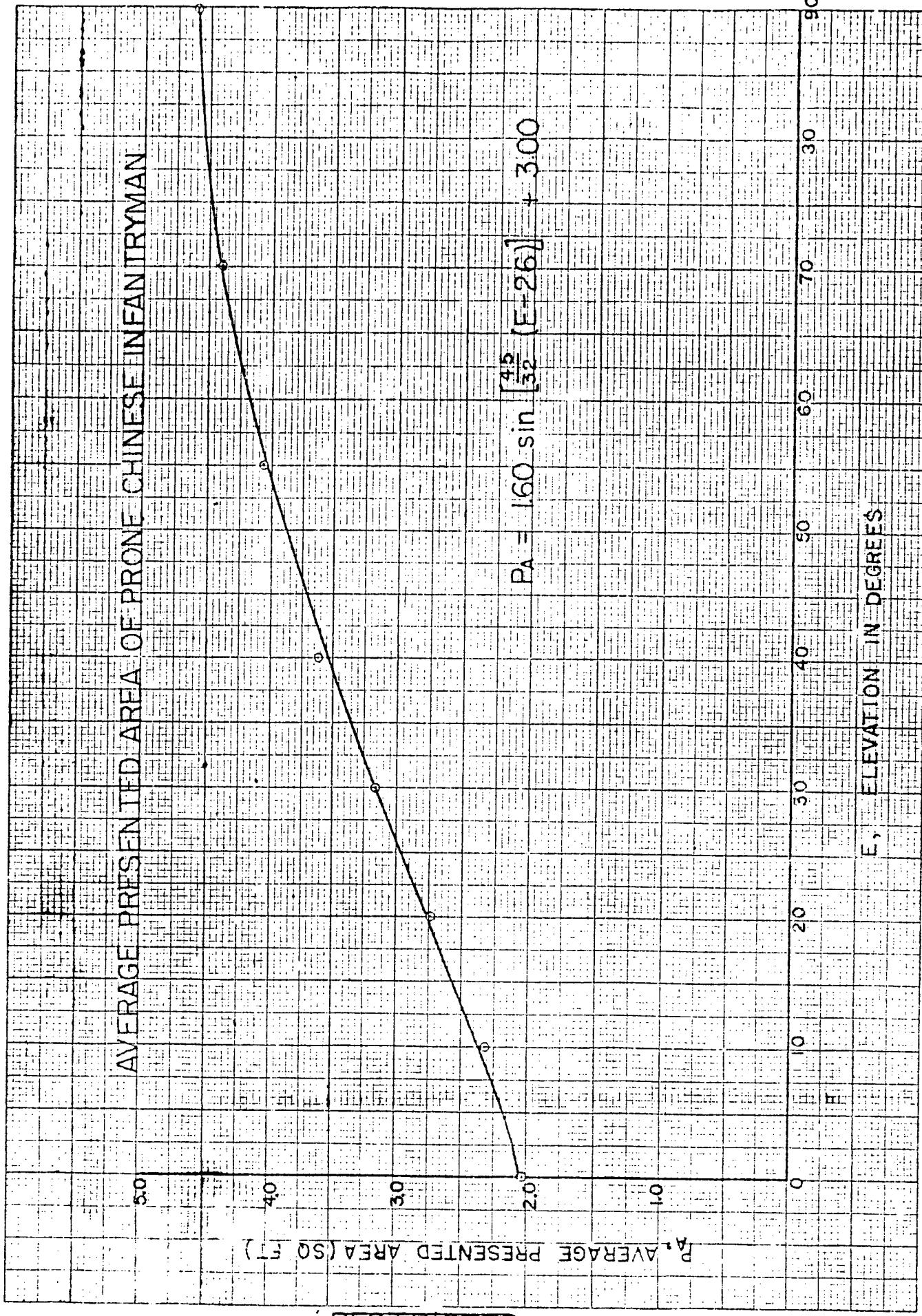
Elevation (deg)	Azimuth (deg)	Planimetered Area of Silhouette (Fig. 3) (sq in.)	S.F. Scaling Factor (Fig. 4)	S.F. Presented Area of Wooden Model (sq in.)	S.F. Presented Area of Chinese Infantry- man (sq in.)	$\frac{100(S \cdot F)}{Tm}$	$\frac{100(S \cdot F)}{Tm}$ (sq ft)
70	0	6.20	1.000	6.20	620	4.31	
70	45	6.40	1.000	6.40	640	4.44	
70	90	6.50	0.985	6.40	640	4.44	
70	135	6.41	0.985	6.31	631	4.38	
70	180	6.30	0.985	6.21	621	4.31	
					(Avg.)	4.40	
90	-	6.72	0.985	6.62	662	4.60	
					(Avg.)	4.60	

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FIG. 7



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Number

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- 3 R. Martin, Lehrbuch der Anthropologie, Jena: Gustav Fischer, Volume II, pp. 251-255, 1928.

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